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Assessment of the energy potential of pig dung by the production of biogas in the urban municipality from N'Zérékoré in Guinea

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Abstract
This present work concerns the trial to evaluate the energy potential of pig dung by the production of biogas in the urban municipality of N'Zérékoré. In order to achieve the expected results, we carried out: a census of the pig herd, an evaluation of the average daily production of dung, a physicochemical characterization of the samples and an evaluation of the energy potential of the pig dung of the locality. The main results obtained are: the pig herd in the city (4845), the average daily production of dung per animal (2.30 kg/d), the total daily quantity of dung (11143.5 kg/d), the parameters physicochemicals of pig slurry, humidity (53.83%); dry matter (44.26%); organic matter per dry matter (81.39%); density (650.36 kg/m^3); Carbon (47.20%); Nitrogen (1.8%) and Carbon per Nitrogen ratios (26.22); daily biogas production (3375.982 m^3/d) and energy potential (15461.996 kWh/d).

Keywords: Characterization, Physicochemicals, Valorization, Dung and Energy potential

1. Introduction
The interest in biogas has increased considerably nowadays through the struggle to reduce the consumption of fossil fuels, as well as to find sustainable environmental solutions in the treatment and recycling of animal droppings and organic waste [1]. The production of biogas or anaerobic digestion is of great interest for subsistence and livestock farming sites. This is particularly the case in the various neighborhoods of the city of N'Zérékoré in the Republic of Guinea [2]. This anaerobic digestion promotes the daily accessibility of local populations to clean energy and quality fertilizers for arable land [3]. The production of biogas from plant waste, animal droppings, industrial waste, sludge from purification stations, household waste, etc., allows better management and recovery of this waste [4]. The production of biogas by the anaerobic biological digestion of biomass is one of the future pathways to help reduce our dependence on fossil fuels [5]. The breeding of semi-improved pigs is now carried out everywhere in Forest Guinea and especially in the Prefecture of N'Zérékoré. This breeding produces a large quantity of dung each year, the recovery of which remains a problem. Thus, the objective of this study is to test the energy potential in biogas of pig dung in the Urban Municipality of N'Zérékoré.

2. Materials and methods
2.1 Presentation of the study area
N'Zérékoré prefecture is one of the prefectures of Forest Guinea (south-eastern region of Guinea). It is the third largest prefecture in the country after the capital Conakry and the prefecture of Kankan. This region includes, in addition to the prefecture of N'Zérékoré, the prefectures of Macenta, Guéckédou, Beyla, Lola and Yomou. N'Zérékoré is located between 7°32 and 8°22 North latitude and 9°04 West longitude and covers an area of 47.3km2. N'Zérékoré is at an altitude of 480 m, its relief is rugged. The climate is of the subequatorial type characterized by the alternation of two main seasons: a rainy season from March to November and a dry season from November to March, the average annual temperature is 26°C [6]. The population of N'Zérékoré is estimated at 396949 inhabitants, including 202894 women (September 2018). Agriculture is the main activity in the area, sheep, goat and pig farming is practiced throughout the prefecture. The pig herd is the most important in the areas of the N'Zérékoré prefecture. The environmental, cultural and socio-economic conditions favor the breeding of pigs in N'Zérékoré. Hence the choice of this study area. The map of the urban municipality of N'Zérékoré is illustrated in fig 1 [7].

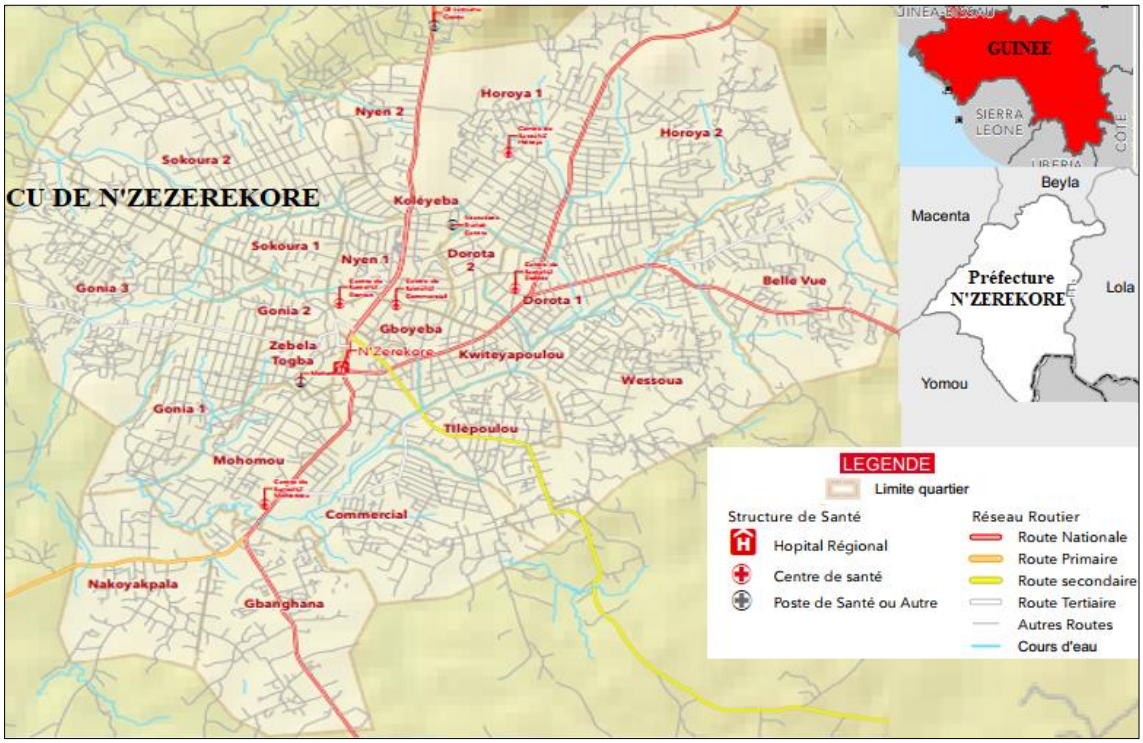


Fig 1: Map of the urban municipality of N'Zérékoré

2.3 Material

The materials used are: Sampling (plastic bottles, cooler, gloves, boots, muffle oven, oven, desiccator, incinerator, electronic balance, analytical balance and containers graduated in centiliter); Energy potential assessment (census sheets, polyethylene bags, markers, survey sheets, shovels, buckets, boots, gloves, nose guards, wheelbarrows and hook scales).

2.4 Methods

The methodology adopted consists in carrying out: the field survey for the census of pig herds in the urban municipality of N'Zérékoré in order to assess the average daily production of waste per animal; the analysis of samples, for the determination of the physicochemical parameters of the waste and the determination of the biogas potential.

The daily production of pig manure was determined by measuring the mass of waste produced by a given number of animals, using a 100 kg scale. This quantity of a given animal population is calculated by relation 1 [8].

$$Q_j=P_{mj}\times N_a \quad (1)$$

Where: Qj - Daily quantity of waste in (kg/d); Pmj - Average daily waste production of an animal (kg/head/day); Na - Animal population.

The biogas and methane productivity of the waste depends on the rates of dry matter (DM), organic matter (OM), specific productions of biogas and methane for a deposit of animal waste. The daily quantity of organic matter is calculated by relation 2. The daily biogas and methane productivities per OM are determined by relations 3 and 4.

$$MO=N_a\times 〖Q〗_j\times\%MO \quad (2)$$

$$P_{biog}=MO\times(\%biog/MO) \quad (3)$$

$$P_{(CH_4)}=P_{biog}\times 〖\%CH〗_4 \quad (4)$$

Where: OM - Organic matter available per day (m3/d) or (kg/d); Na - Number of animals according to categories; Qj - Quantity of waste produced per day in (m3/d); % OM - Rate of organic matter per dry matter; Pbiog - Daily production of biogas in liters per day (m3/d); % biogas/OM - Average content of biogas per organic matter (m3/kg OM); PCH4 - Daily production of methane (m3/d) and % CH4 - Rate of methane contained in the biogas.

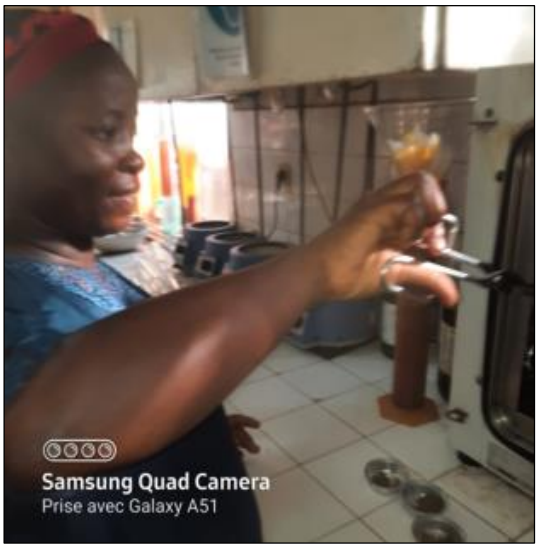
The energy potentials are a function of the level of methane in the biogas and of its Lower Calorific Value [9]. The PCI of methane is 9.94 kWh/Nm3 or 35,784 kJ/Nm3 and 1m3 of biogas containing 50% methane is equivalent on average to 4.58 kWh of electricity or 16,488 kJ [10]. The daily energy potential is determined by relation 5:

$$P_{Energ}=P_{(CH_4)}\times PCI_{CH4} \quad (5)$$

Where: PEnerg - Daily energy production from biogas (kJ/d); PCICH4 - Lower Calorific Value of methane (kJ/m3).

The pig dung samples were taken from the farms of the urban commune of N'Zérékoré on December 2, 2020 transported in hermetic polypropylene bottles for analyzes in the control and quality laboratories of the Société Guinéenne de Palmiers à Huile and Hévéas de Diecké. Thus, the gravimetric method was used for the determination of the following parameters: density (Mv), humidity (H), amounts of dry matter (DM) and organic matter (OM). The volumetric method made it possible to determine the Organic Carbon (CO) according to the French standard NFU44-161 and Total Nitrogen (NT) was determined by the Kjeldahl method [11]. The images in Fig 2 and 3 show the process of collecting, weighing and physicochemical characterization of the dung.

Fig 2: Collection and weighing process



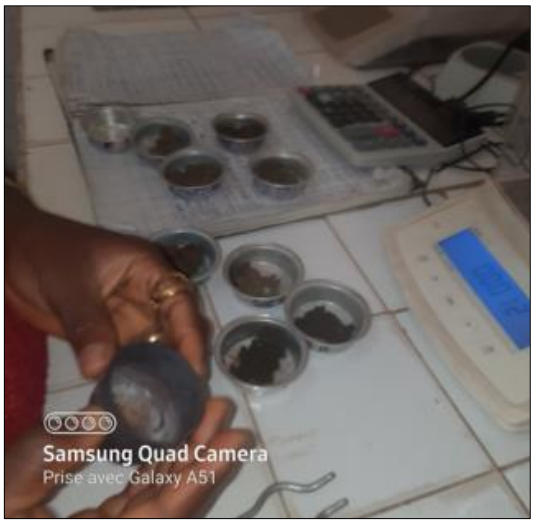


Fig 3: Physicochemical characterization process

3. Results and discussions

3.1 Results

3.1.1 Physicochemical parameters of pig dung

The physicochemical parameters of pig dung from the urban municipality of N'Zérékoré are shown in Tables 1.

Table 1: Physicochemical parameters of pig dung

Substrate	H(%)	MS(%)	MO(%)	ρ(kg/m^3)	C(%)	N(%)	C/N
Pig dung	53,83	44,26	81,39	650,36	47,20	1,8	26,22

Table 2: Average daily production of pig slurry

Substrate	Our results	Literatur [4, 12]
Pig dung (kg/j)	2,30	1 at 3

3.1.2 Average daily production of pig weavers
The average daily quantity of pig manure produced in pigsties in the urban municipality of N'Zérékoré is given in Table 2.

3.1.3 Energy potential of pig slurry
The results of the evaluation of the daily energy potential of pig dung by district of the city of N'Zérékoré are given in Table 3.

Table 3: Daily energy potential of dung

N°	Quartiers	Staff	Qty dung (kg/d)	MS (kg/d)	MO (kg/j)	Biogas (m^3/d)	Energy kWh/d
1	Gbanghana	750	1725,000	763,485	621,400	522,598	2393,498
2	Nakoyakpala	570	1311,000	580,249	472,264	397,174	1819,058
3	Tilèpoulou	542	1246,600	551,745	449,065	377,664	1729,701
4	Kwiteyapoulou	450	1035,000	458,091	372,840	313,559	1436,099
5	Mohomou	425	977,500	432,642	352,127	296,139	1356,315
6	Nyen 2	420	966,000	427,552	347,984	292,655	1340,359
7	Gonia 2	368	846,400	374,617	304,900	256,421	1174,410
8	Nyen 1	315	724,500	320,664	260,988	219,491	1005,269
9	Wessoua	242	556,600	246,351	200,505	168,625	772,302
10	Gonia 3	214	492,200	217,848	177,306	149,115	682,945
11	Gonia 1	178	409,400	181,200	147,479	124,030	568,057
12	Sokoura 2	125	287,500	127,248	103,567	87,100	398,916
13	Horoya 1	86	197,800	87,546	71,254	59,925	274,454
14	Belle Vue	85	195,500	86,528	70,425	59,228	271,263
15	Horoya 2	75	172,500	76,349	62,140	52,260	239,350
TOTAL		4845	11143,500	4932,113	4014,247	3375,982	15461,996

3.2 Discussions
For a good interpretation and discussion of the results obtained, we have presented them by diagrams and curves.

3.2.1 Physicochemical parameters of pig dung
The physicochemical parameters of pig dung from the urban municipality of N'Zérékoré are represented by the diagrams in Fig 4.

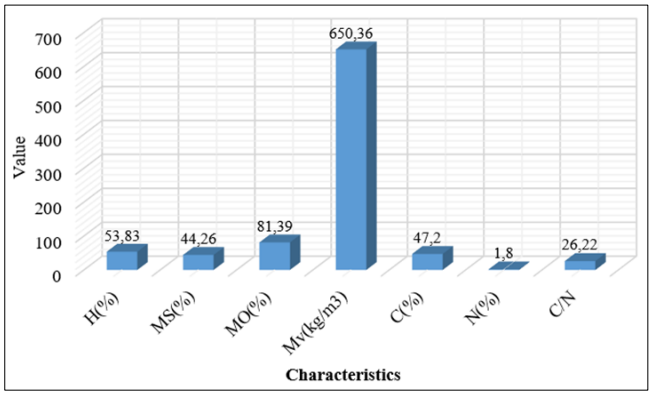


Fig 4: Physicochemical parameters of slurry

Figure 4 shows that the values of the physicochemical parameters of pig dung from the city of N'Zérékoré are on average: humidity (53.83%); dry matter (44.26%); organic matter (81.39%); density (650.36kg/m3); Carbon (47.20%); Nitrogen (1.8%) and ratios between Carbon and Nitrogen (26.22). These physicochemical parameters generally depend on the breeding method. The results obtained are consistent with those of other authors and are favorable to the optimal production of biogas [2, 4].

3.2.2 Average daily production of pig manure
The average daily quantity of pig slurry produced in the N'Zérékoré pigsties is represented by the diagram in Fig 5.

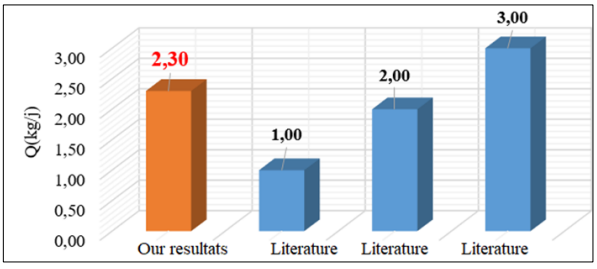


Fig 5: Average daily production of pig slurry

The diagrams in Figure 5 show that the average daily value of pig manure in the municipality is (2.30 kg/d). This result is included in the range of average daily production of pig excrement, ie 1 to 3 kg [12]. This daily production depends on the method of breeding and the state of health of the animal [4].

3.2.3 Energy potential of pig manure
The daily energy potential of pig dung by district of the Urban Municipality of N'Zérékoré is illustrated by the diagrams in Fig 3.

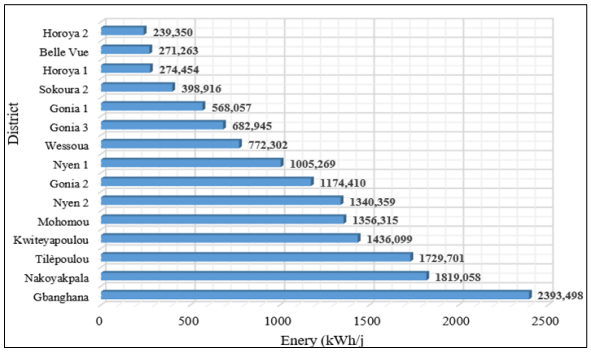


Fig 6: Daily energy potential of pig dung

The daily gross energy potential of pig manure from 15 neighborhoods in 34 neighborhoods in the city of N'Zérékoré is 15461.996 kWh/d, or a powerful gross amount of 644.50kW; with an annual average value of 235151.20 kW. This energy could cover part of the energy needs (lighting and cooking) of the various farm locations in the city.

4. Conclusion

The present study consisted of the test to evaluate the energy potential of pig dung by the production of biogas. The results obtained constitute a first estimate of the energy potential of pig dung in the city of N'Zérékoré. The energy recovery of these types of livestock waste would make it possible to produce clean energy locally. This resource could cover part of the energy needs (lighting and cooking) of the various farms in the city. The experimental production of biogas from these pig dung in mono and co-digestion with other substrates will be the subject of research.

5. References

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